



(12) **United States Patent**
Choi

(10) **Patent No.:** **US 9,208,834 B2**
(45) **Date of Patent:** **Dec. 8, 2015**

(54) **LATCH CIRCUIT, NONVOLATILE MEMORY
DEVICE AND INTEGRATED CIRCUIT**

USPC 365/189.05, 189.15, 189.16, 230.06
See application file for complete search history.

(71) Applicant: **SK hynix Inc.**, Gyeonggi-do (KR)

(56) **References Cited**

(72) Inventor: **Sung-Dae Choi**, Gyeonggi-do (KR)

U.S. PATENT DOCUMENTS

(73) Assignee: **SK Hynix Inc.**, Gyeonggi-do (KR)

2006/0034142 A1* 2/2006 Ooishi et al. 365/230.06
2007/0297228 A1* 12/2007 Song et al. 365/185.08
2009/0295770 A1 12/2009 Woo et al.
2012/0081979 A1* 4/2012 An 365/189.16
2012/0140572 A1* 6/2012 Kim et al. 365/189.05

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 153 days.

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **13/866,691**

KR 100965773 6/2010

(22) Filed: **Apr. 19, 2013**

* cited by examiner

(65) **Prior Publication Data**

US 2013/0279273 A1 Oct. 24, 2013

Primary Examiner — Richard Elms

Assistant Examiner — Ajay Ojha

(30) **Foreign Application Priority Data**

(74) *Attorney, Agent, or Firm* — IP & T Group LLP

Apr. 23, 2012 (KR) 10-2012-0042173

(57) **ABSTRACT**

(51) **Int. Cl.**
G11C 7/10 (2006.01)
G11C 16/30 (2006.01)
G11C 16/32 (2006.01)
H03K 3/012 (2006.01)
H03K 3/356 (2006.01)

A latch circuit may include a plurality of latches configured to operate in response to power supplied to a pull-up power supply node and a pull-down power supply node, a delay unit configured to generate a 1st delayed reset signal and a 2nd delayed reset signal by delaying a 1st reset signal and a 2nd reset signal, a power supply unit configured to supply identical power to the pull-up power supply node and the pull-down power supply node in response to the activated 1st reset signal or the activated 2nd reset signal, a 1st reset unit configured to reset a plurality of latches to a 1st level in response to the 1st delayed reset signal and a 2nd reset unit configured to reset the plurality of latches to a 2nd level in response to the 2nd delayed reset signal.

(52) **U.S. Cl.**
CPC **G11C 7/10** (2013.01); **G11C 16/30** (2013.01);
G11C 16/32 (2013.01); **H03K 3/012** (2013.01);
H03K 3/356 (2013.01); **G11C 2216/14**
(2013.01)

(58) **Field of Classification Search**

CPC G11C 7/106; G11C 7/1087; G11C 7/12

20 Claims, 10 Drawing Sheets

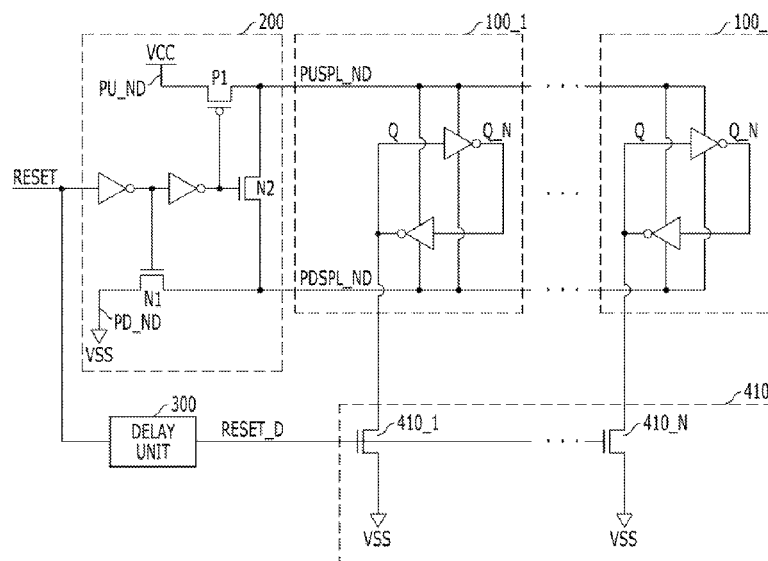


FIG. 2

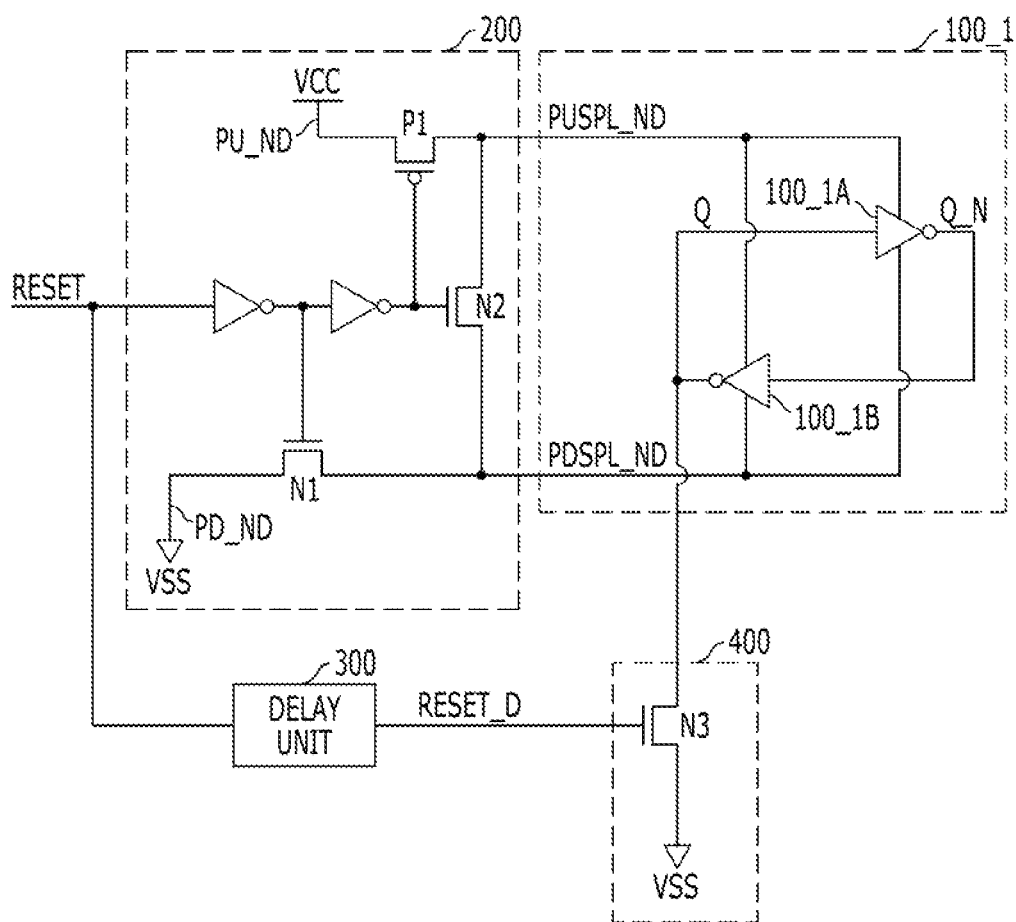


FIG. 3

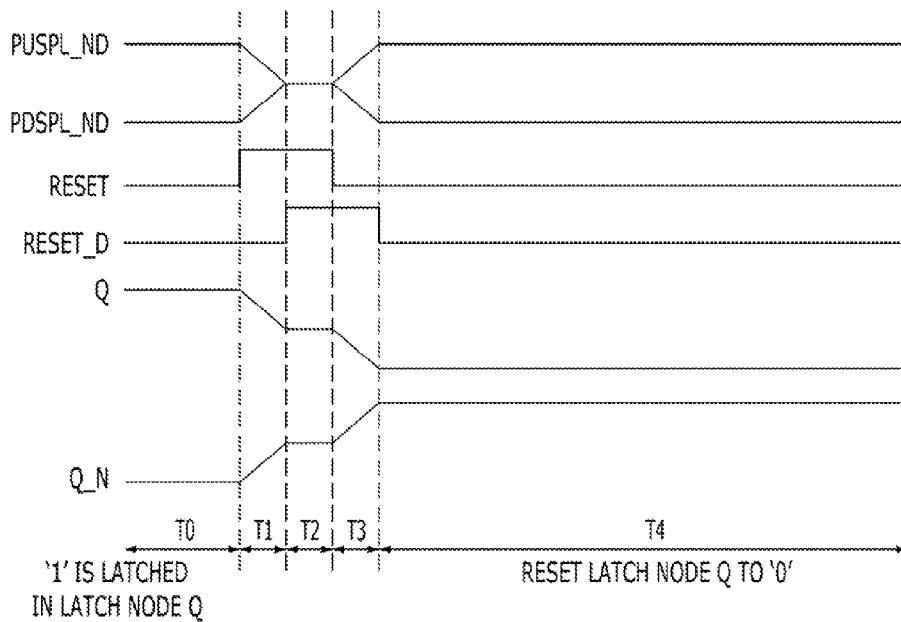


FIG. 4

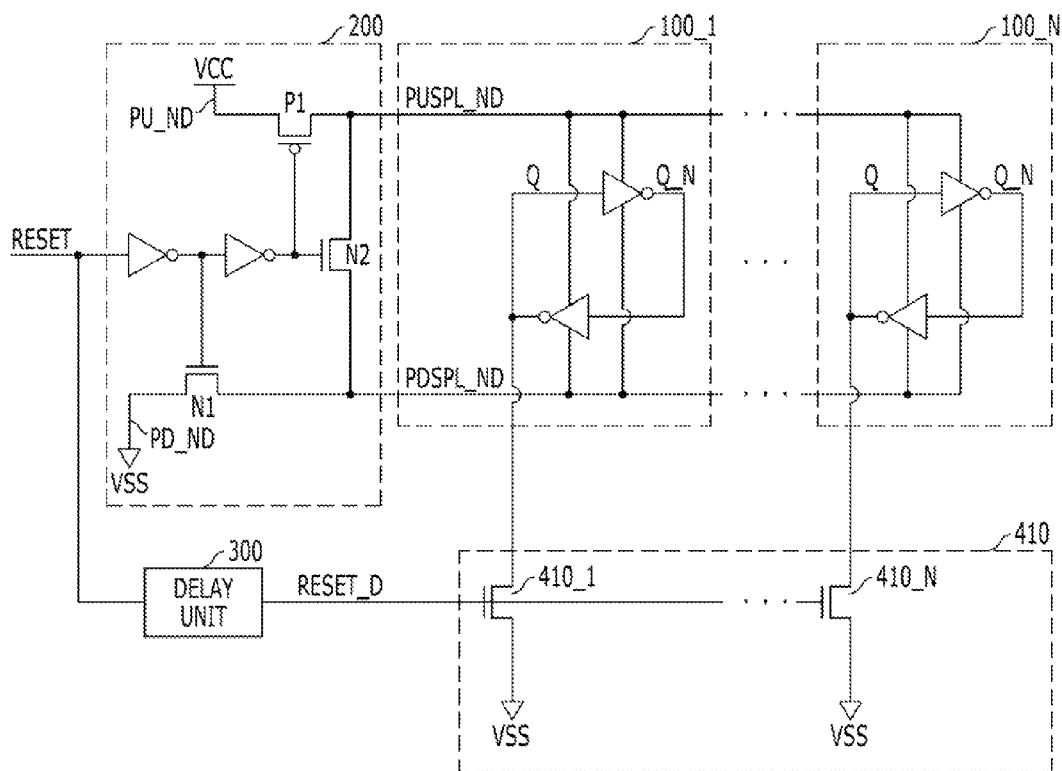


FIG. 5

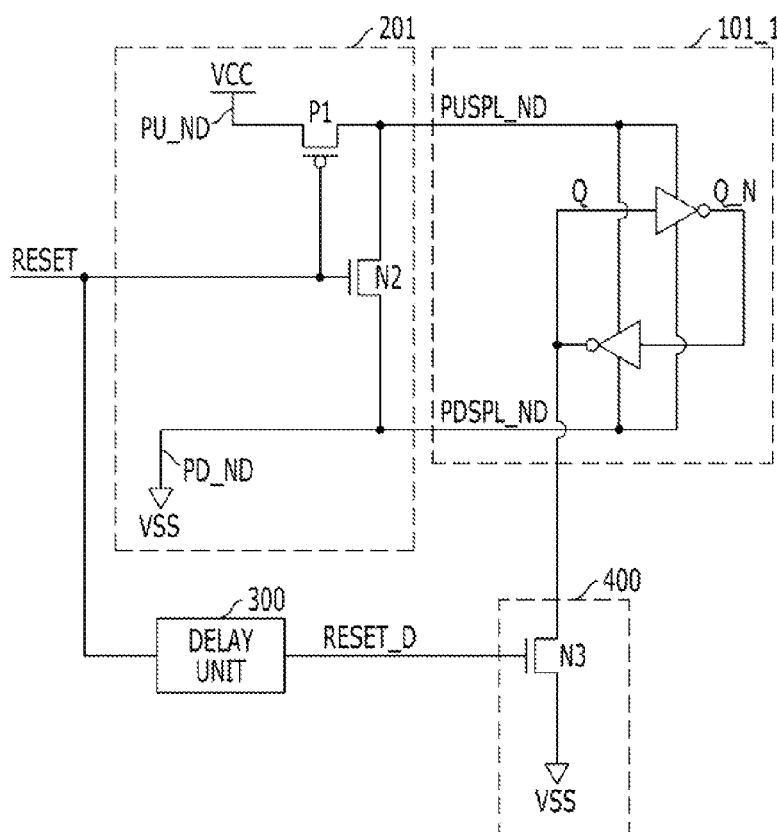


FIG. 6

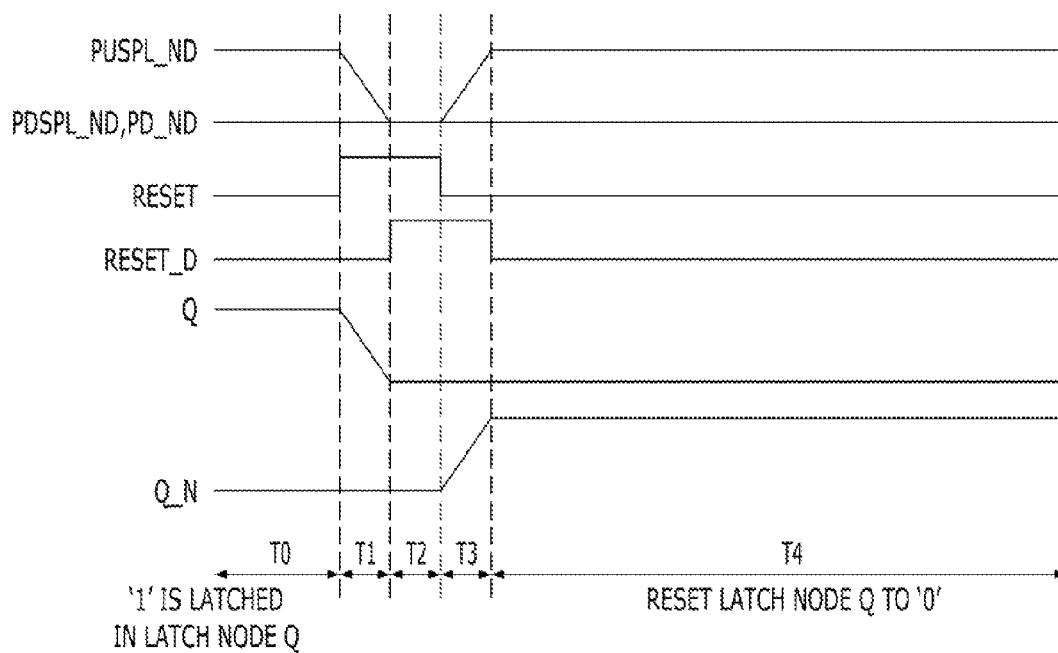


FIG. 7

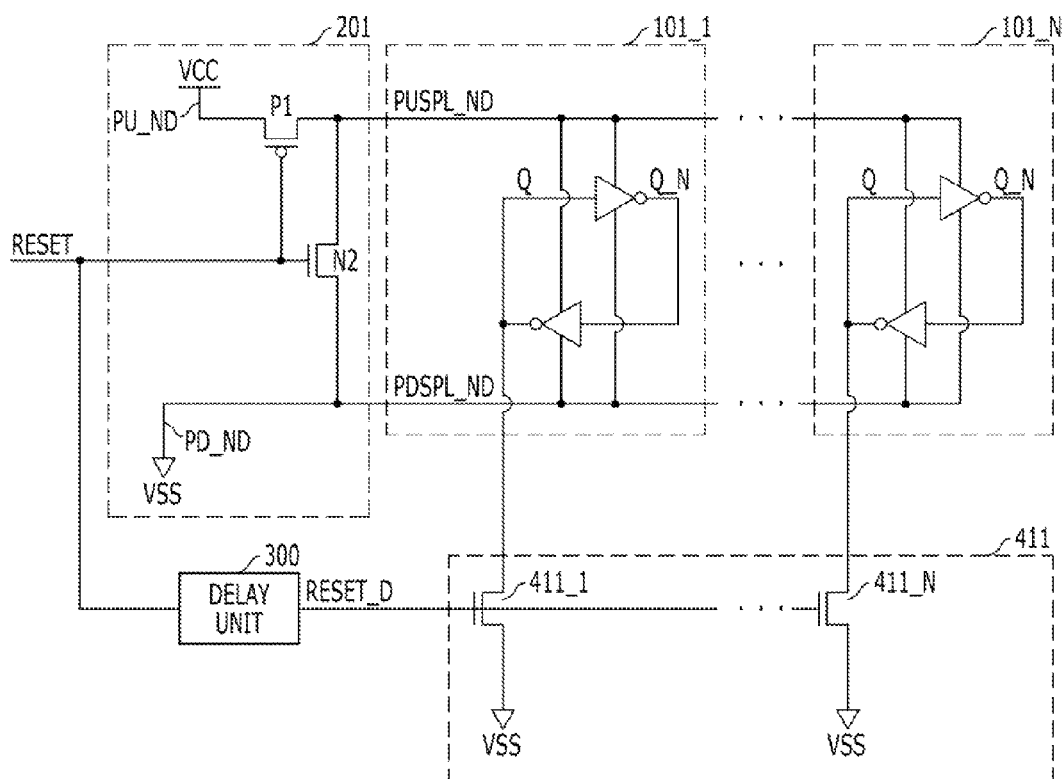


FIG. 8

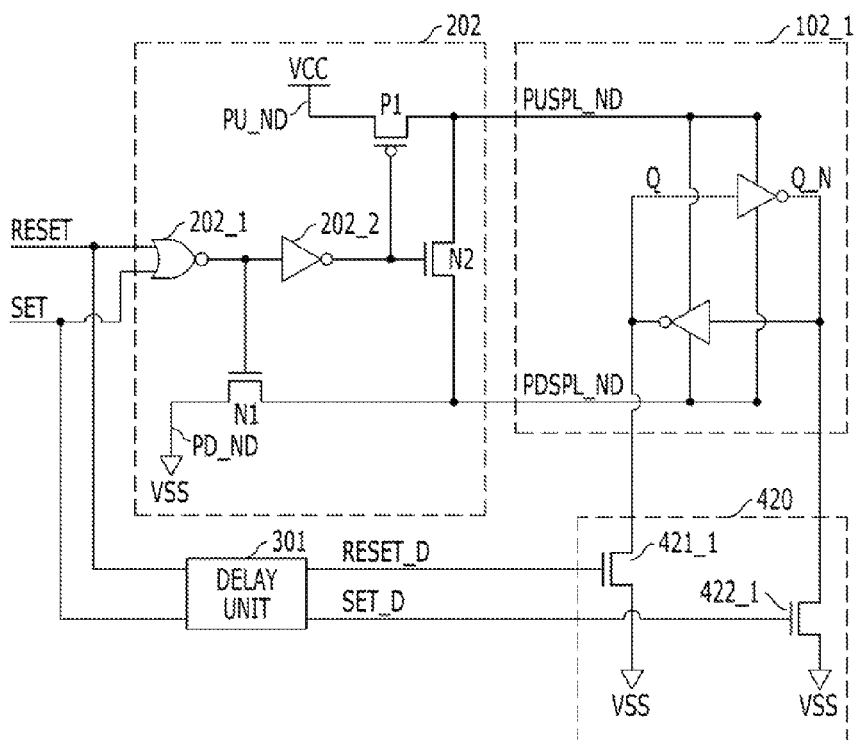


FIG. 9

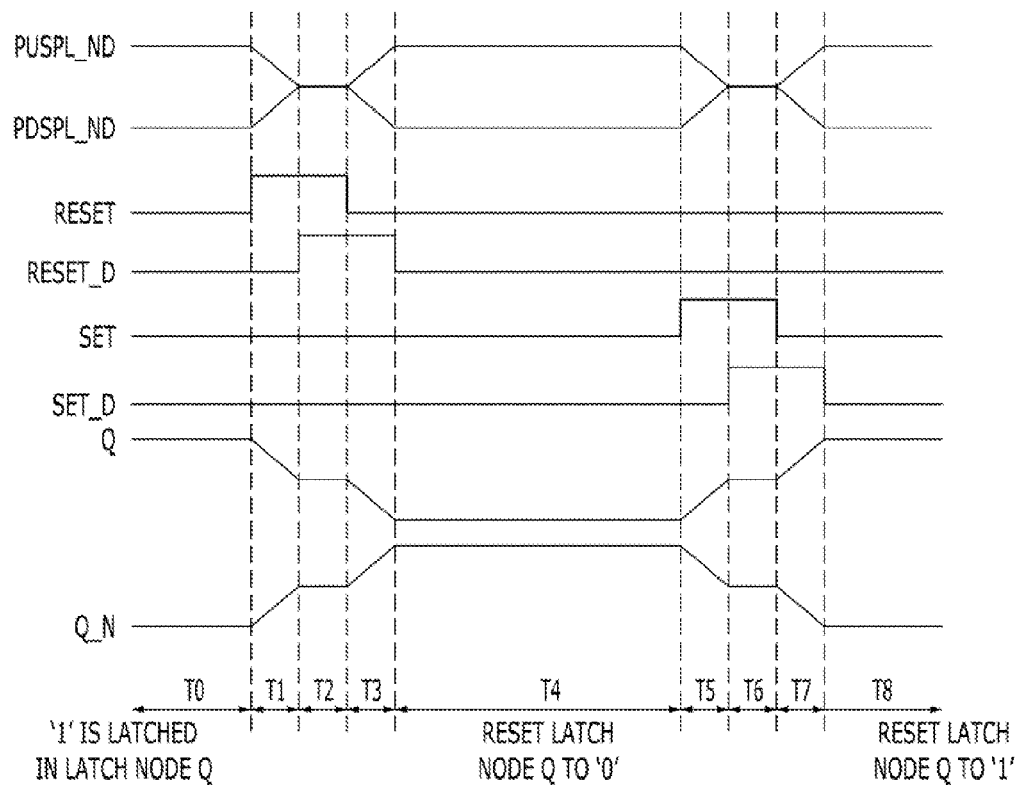


FIG. 10

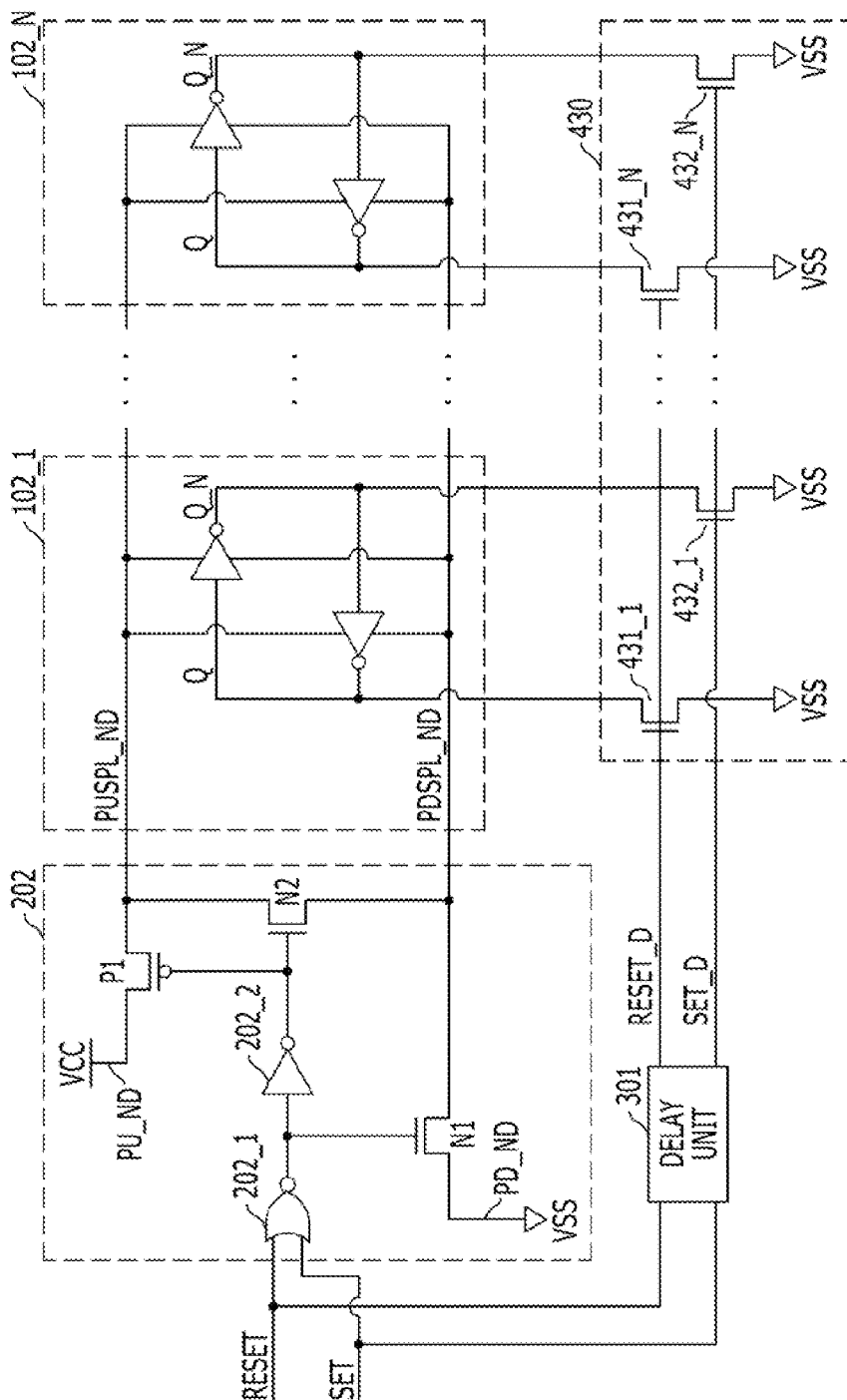


FIG. 11

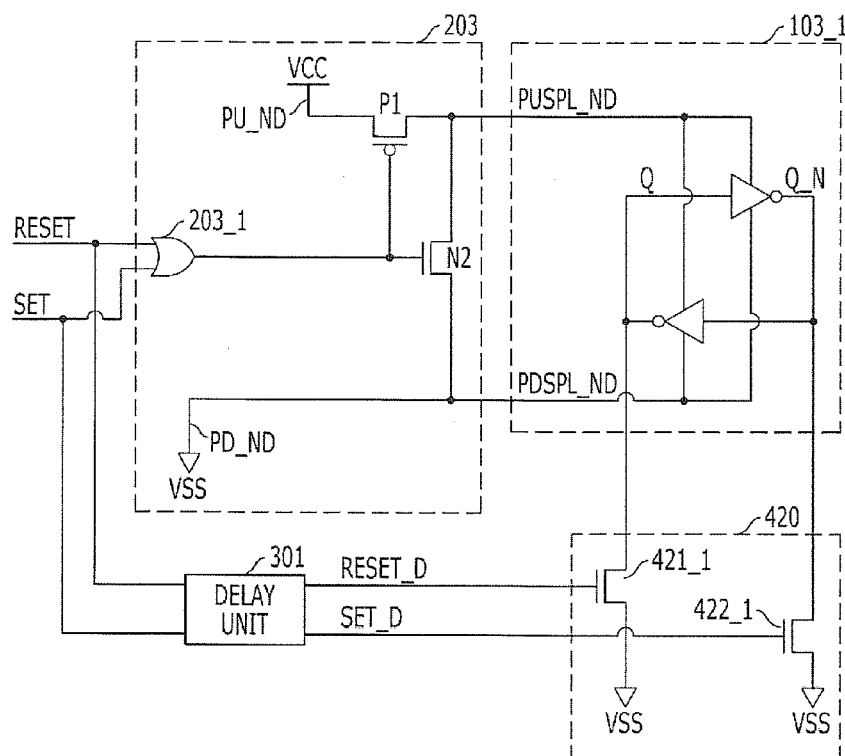


FIG. 12

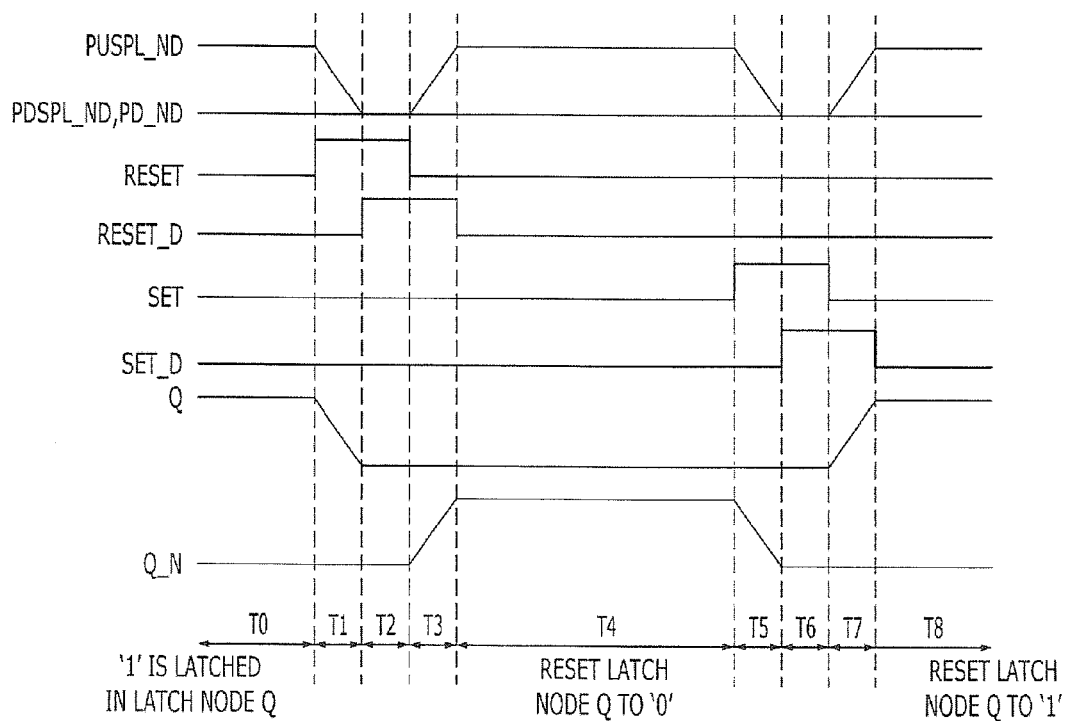


FIG. 13

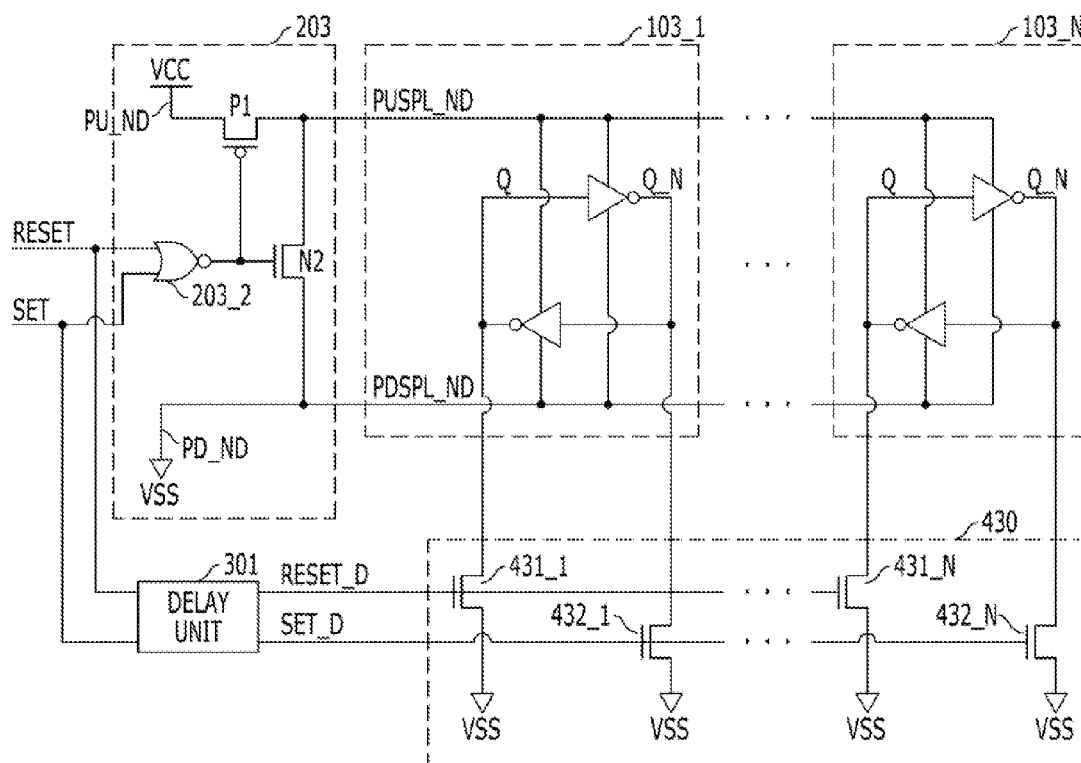
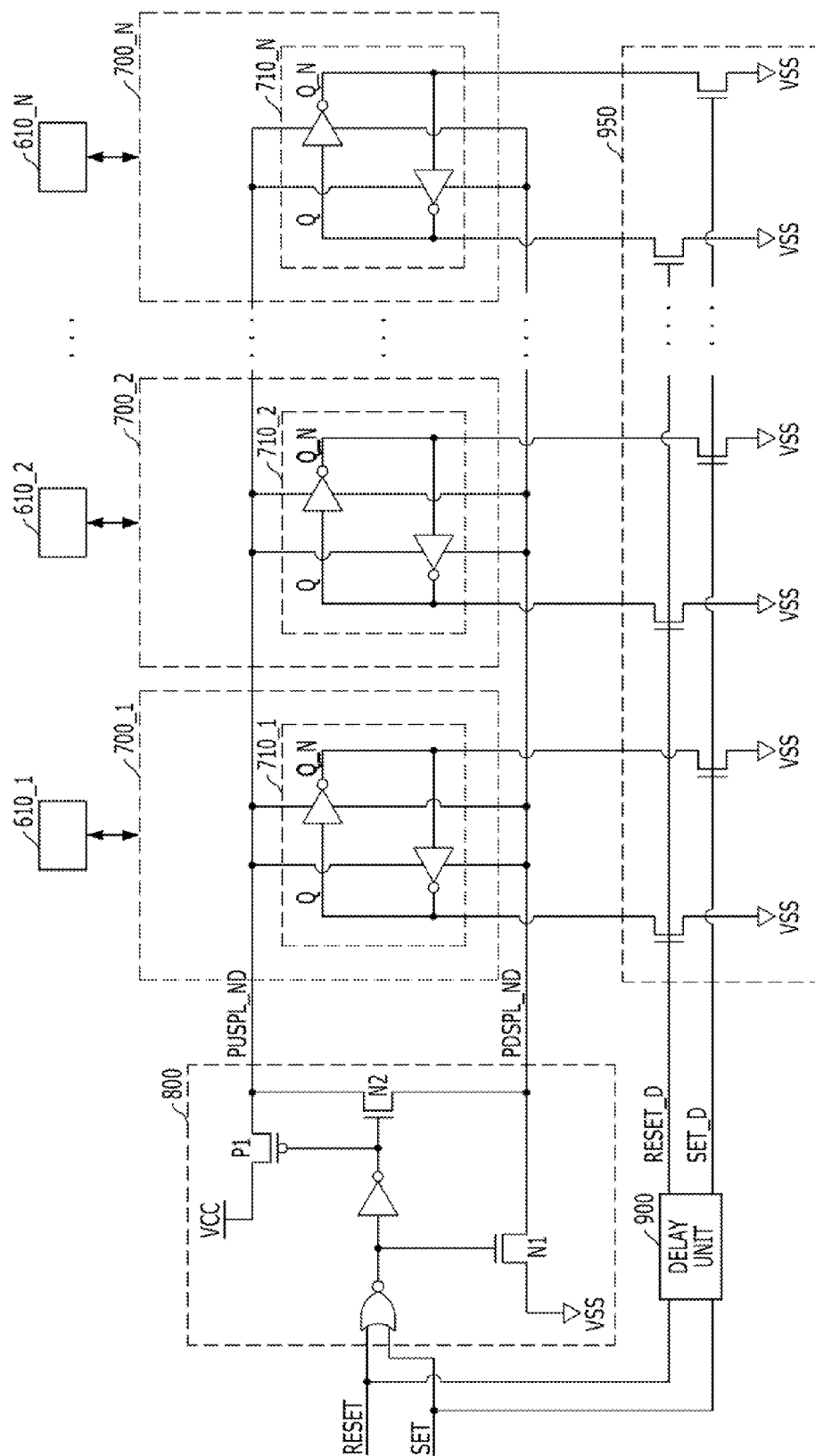


FIG. 14



1

LATCH CIRCUIT, NONVOLATILE MEMORY DEVICE AND INTEGRATED CIRCUIT

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority of Korean Patent Application No. 10-2012-0042173, filed on Apr. 23, 2012, which is incorporated herein by reference in its entirety.

BACKGROUND

1. Field

Exemplary embodiments of the present invention relate to a latch circuit and a nonvolatile memory device including the latch circuit.

2. Description of the Related Art

An integrated circuit chip, such as a memory device, includes a latch circuit in order to maintain data for some time period.

FIG. 1 is a diagram showing a conventional latch circuit.

The latch circuit includes N latches **10_1~10_N** and a reset unit **20**.

Each of the latches **10_1~10_N** latches data in response to a core voltage VCC supplied to a pull-up power supply node PUSPL_ND and a ground voltage VSS supplied to a pull-down power supply node PDSPL_ND.

The reset unit **20** resets the latches **10_1~10_N** to a low level when a 1st reset signal RESET is activated and resets the latches **10_1~10_N** to a high level when a 2nd reset signal SET is activated.

For the reset of the latches **10_1~10_N** to a low level, the 1st reset signal RESET is activated. The 1st transistors **21_1~21_N** of the reset unit **20** are turned on in response to the activated 1st reset signal RESET, and thus the 1st latch node Q of each of the latches **10_1~10_N** is grounded (VSS). Accordingly, the voltage level of the 1st latch node Q is lowered because of discharge of the 1st latch node Q. The voltage of each of the 2nd latch nodes Q_N of the latches **10_1~10_N** becomes a level of the core voltage VCC, and the voltage of the 1st latch node Q becomes a level of the ground voltage VSS. When the 1st reset signal RESET becomes a low level and thus the 1st transistors **21_1~21_N** are turned off, the 1st latch nodes Q of the latches **10_1~10_N** maintain voltage of a low level by the voltage of the pull-down power supply node PDSPL_ND and the 2nd latch nodes Q_N maintain voltage of a high level by the voltage of the pull-up power supply node PUSPL_ND.

For the reset of the latches **10_1~10_N** to a high level, the 2nd reset signal SET is activated. In this case, the operations of the latches **10_1~10_N** are opposite to those when the latches **10_1~10_N** are reset to a low level. The 2nd transistors **22_1~22_N** of the reset unit **20** are turned on in response to the activated 2nd reset signal SET, and thus the 2nd latch node Q_N of each of the latches **10_1~10_N** is grounded (VSS). Accordingly, the voltage level of the 2nd latch node Q_N is lowered because discharge of the 2nd latch node Q_N. The voltage of the 1st latch node Q becomes a level of the core voltage VCC, and the voltage of the 2nd latch node Q_N becomes a level of the ground voltage VSS. When the 2nd reset signal SET becomes a low level and thus the 2nd transistors **22_1~22_N** are turned off, the voltage of each of the 1st latch nodes Q of the latches **10_1~10_N** maintains a high level by the voltage of the pull-up power supply node PUSPL_ND, and the voltage of each of the 2nd latch nodes Q_N of the latches **10_1~10_N** maintains a low level by the voltage of the pull-down power supply node PDSPL_ND.

2

If a value stored in each of the latches **10_1~10_N** is different from a value to be reset, however, a lot of a current is consumed in order to reset the latches **10_1~10_N**. In particular, in a system including the latch circuit, an excessive peak current is induced due to the reset of latches.

SUMMARY

Exemplary embodiments of the present invention are directed to a latch circuit for resetting latches with a minimum current and a minimum reset time.

In accordance with an embodiment of the present invention, a latch circuit may include a latch configured to operate in response to power supplied to a pull-up power supply node and a pull-down power supply node; a delay unit configured to generate a delayed reset signal by delaying a reset signal; a power supply unit configured to supply identical power to the pull-up power supply node and the pull-down power supply node in response to the reset signal; and a reset unit configured to reset the latch to a 1st level in response to the delayed reset signal.

In accordance with another embodiment of the present invention, a latch circuit may include a plurality of latches configured to operate in response to power supplied to a pull-up power supply node and a pull-down power supply node; a delay unit configured to generate a delayed reset signal by delaying a reset signal; a power supply unit configured to supply identical power to the pull-up power supply node and the pull-down power supply node in response to the reset signal; and a reset unit configured to reset a plurality of latches to a 1st level in response to the delayed reset signal.

In accordance with another embodiment of the present invention, a latch circuit may include a latch configured to operate in response to power supplied to a pull-up power supply node and a pull-down power supply node; a delay unit configured to generate a 1st delayed reset signal and a 2nd delayed reset signal by delaying a 1st reset signal and a 2nd reset signal; a power supply unit configured to supply identical power to the pull-up power supply node and the pull-down power supply node in response to the activated 1st reset signal or the activated 2nd reset signal; a 1st reset unit configured to reset a latch included in the latch circuit to a 1st level in response to the 1st delayed reset signal; and a 2nd reset unit configured to reset the latch to a 2nd level in response to the 2nd delayed reset signal.

In accordance with another embodiment of the present invention, a latch circuit may include a plurality of latches configured to operate in response to power supplied to a pull-up power supply node and a pull-down power supply node; a delay unit configured to generate a 1st delayed reset signal and a 2nd delayed reset signal by delaying a 1st reset signal and a 2nd reset signal; a power supply unit configured to supply identical power to the pull-up power supply node and the pull-down power supply node in response to the activated 1st reset signal or the activated 2nd reset signal; a 1st reset unit configured to reset a plurality of latches to a 1st level in response to the 1st delayed reset signal; and a 2nd reset unit configured to reset the plurality of latches to a 2nd level in response to the 2nd delayed reset signal.

In accordance with yet another embodiment of the present invention, a nonvolatile memory device may include a memory cell; a page buffer configured to access data stored in the memory cell and comprising one or more latches operating in response to power supplied to, a pull-up power supply node and a pull-down power supply node; a delay unit configured to generate a delayed reset signal by delaying a reset signal; a power supply unit configured to supply identical

3

power to the pull-up power supply node and the pull-down power supply node in response to the reset signal; and a reset unit configured to reset the one or more latches to a 1st level in response to the delayed reset signal.

In accordance with yet another embodiment of the present invention, a nonvolatile memory device may include a plurality of memory cells; a plurality of page buffers configured to access data stored in the respective memory cells and each comprising one or more latches operating in response to power supplied to a pull-up power supply node and a pull-down power supply node; a delay unit configured to generate a 1st delayed reset signal and a 2nd delayed reset signal by delaying a 1st reset signal and a 2nd reset signal; a power supply unit configured to supply identical power to the pull-up power supply node and the pull-down power supply node in response to the activated 1st reset signal or the activated 2nd reset signal; and a reset unit configured to reset the one or more latches to a 1st level in response to the 1st delayed reset signal, and reset the one or more latches to a 2nd level in response to the 2nd delayed reset signal.

In accordance with yet another embodiment of the present invention, a integrated circuit may include a plurality of memory cells, a plurality of access units configured to access data stored in the respective memory cells and each comprising one or more latches operating in response to power supplied to a pull-up power supply node and a pull-down power supply node, a delay unit configured to generate a 1st delayed reset signal and a 2nd delayed reset signal by delaying a 1st reset signal and a 2nd reset signal a power supply unit configured to supply identical power to the pull-up power supply node and the pull-down power supply node in response to the activated 1st reset signal or the activated 2nd reset signal and a reset unit configured to reset the one or more latches to a 1st level in response to the 1st delayed reset signal, and reset the one or more latches to a 2nd level in response to the 2nd delayed reset signal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating a conventional latch circuit.

FIG. 2 is a diagram illustrating a latch circuit in accordance with a 1st embodiment of the present invention.

FIG. 3 is a timing diagram illustrating the reset operation of the latch circuit shown in FIG. 2.

FIG. 4 is a diagram illustrating a latch circuit in accordance with a 2nd embodiment of the present invention.

FIG. 5 is a diagram illustrating a latch circuit in accordance with a 3rd embodiment of the present invention.

FIG. 6 is a timing diagram illustrating the reset operation of the latch circuit shown in FIG. 5.

FIG. 7 is a diagram illustrating a latch circuit in accordance with a 4th embodiment of the present invention.

FIG. 8 is a diagram illustrating a latch circuit in accordance with a 5th embodiment of the present invention.

FIG. 9 is a timing diagram illustrating the reset operation of the latch circuit shown in FIG. 8.

FIG. 10 is a diagram illustrating a latch circuit in accordance with a 6th embodiment of the present invention.

FIG. 11 is a diagram illustrating a latch circuit in accordance with a 7th embodiment of the present invention.

FIG. 12 is a timing diagram illustrating the reset operation of the latch circuit shown in FIG. 11.

FIG. 13 is a diagram illustrating a latch circuit in accordance with an 8th embodiment of the present invention.

4

FIG. 14 is a diagram illustrating a nonvolatile memory device in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

Exemplary embodiments of the present invention will be described below in more detail with reference to the accompanying drawings. The present invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the present invention to those skilled in the art. Throughout the disclosure, reference numerals correspond directly to the like numbered parts in the various figures and embodiments of the present invention. It is also noted that in this specification, “connected/coupled” refers to one component not only directly coupling another component but also indirectly coupling another component through an intermediate component. In addition, a singular form may include a plural form as long as it is not specifically mentioned in a sentence.

The latch circuit in accordance with the present invention is summarized as follows. When one or more latches are to be reset to the 1st level for example, the one or more latches are firstly precharged with voltage having a level between the 1st level and the 2nd level for latched data (for example, voltage of a middle level between the 1st and 2nd levels) and then reset to the 1st level. That is, the latch circuit in accordance with the present invention resets the one or more latches gradually (firstly precharging to a level between the 1st and 2nd levels, and then full-charging to the 1st level). As a result, a peak current may be further lowered as compared with a conventional latch circuit configured to reset one or more latches at once from the 2nd level to the 1st level.

FIG. 2 is a diagram showing a latch circuit in accordance with a 1st embodiment of the present invention.

The latch circuit may include a latch **100_1**, a power supply unit **200**, a delay unit **300**, and a reset unit **400**.

The latch **100_1** latches data in response to voltage sources supplied to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND, 1st and 2nd inverters **100_1A** and **100_1B** respectively inverts the voltages of 1st and 2nd latch nodes Q and Q_N with the power supplied to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND.

The power supply unit **200** supplies power to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND in response to a reset signal RESET. When the reset signal RESET is deactivated, the power supply unit **200** supplies a pull-up voltage VCC to the pull-up power supply node PUSPL_ND and a pull-down voltage VSS to the pull-down power supply node PDSPL_ND. When the reset signal RESET is activated, the power supply unit **200** supplies the same power (for example, voltage between the voltages VCC and VSS) to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND. With the reset signal RESET activated, the power supply unit **200** does not supply the voltages VCC and VSS to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND, but couples and supplies the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND with voltage of a middle level between the voltages VCC and VSS. The power supply unit **200** includes a pull-up power node PU_ND configured to supply a pull-up voltage, and a pull-down power node PD_ND configured to supply a pull-down voltage. A 1st switch P1 couples the pull-up power node PU_ND and the

5

pull-up power supply node PUSPL_ND in response to the deactivated reset signal RESET. A 2nd switch N1 couples the pull-down power node PD_ND and the pull-down power supply node PDSPL_ND in response to the deactivated reset signal RESET. A 3rd switch N2 couples the pull-up and the pull-down power supply nodes PUSPL_ND and PDSPL_ND in response to the activated reset signal RESET.

The delay unit 300 generates a delayed reset signal RESET_D by delaying the reset signal RESET so that the activation periods of the delayed reset signal RESET_D and the reset signal RESET partially overlaps to each other, preferably to a minimum.

The reset unit 400 resets the latch 100_1 to a 1st level in response to the delayed reset signal RESET_D. FIG. 2 illustrates an example in which the reset unit 400 resets the latch 100_1 to a low level when the delayed reset signal RESET_D is activated. The reset unit 400 is turned on in response to the delayed reset signal RESET_D and includes a transistor N3 connected to the ground (VSS) and the 1st latch node Q.

FIG. 3 is a timing diagram showing the reset operation of the latch circuit shown in FIG. 2.

Data of a high level may be latched in the 1st latch node Q of the latch 100_1 prior to the reset operation of the latch circuit. Since the reset signal RESET is a low level during a period T0, the 1st and the 2nd switches P1 and N1 are turned on and the 3rd switch N2 is turned off. Accordingly, the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND are not coupled to each other, but the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND are coupled to each other, so the voltage VCC is supplied to the pull-up power supply node PUSPL_ND. Also the pull-down power node PD_ND and the pull-down power supply node PDSPL_ND are coupled to each other so the voltage VSS is supplied to the pull-down power supply node PDSPL_ND. Accordingly, the voltage of the pull-up power supply node PUSPL_ND becomes a level of the voltage VCC, and the voltage of the pull-down power supply node PDSPL_ND becomes a level of the voltage VSS. The voltage of the 1st latch node Q of the latch 100_1 becomes a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND, and the voltage of the 2nd latch node Q_N becomes a level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND.

In a period T1, the reset signal RESET is activated. In response to the activated reset signal RESET, the 1st and the 2nd switches P1 and N1 are turned off and the 3rd switch N2 is turned on. Accordingly, the coupling of the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND is no longer maintained, the coupling of the pull-down power node PD_ND and the pull-down power supply node PDSPL_ND is no longer maintained, and the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND are coupled. As a result, the voltage of the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND respectively drop and rise to the middle level between the voltages VCC and VSS. As a result, the voltage of the 1st and 2nd latch nodes Q and Q_N respectively drop and rise to levels between the voltages VCC and VSS by the voltage of the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND.

The delay unit 300 generates the delayed reset signal RESET_D whose activation period is overlapped with the activation period of the reset signal RESET for a period T2, by delaying the reset signal RESET. The transistor N3 of the reset unit 400 is turned on in response to the reset signal RESET_D in the period T2, and thus the 1st latch node Q is

6

grounded (VSS). Each of the 1st and 2nd latch nodes Q and Q_N maintains the same voltage of certain levels between the voltages VCC and VSS.

In a period T3, the reset signal RESET is deactivated. In response to the deactivated reset signal RESET, the 1st and the 2nd switches P1 and N1 are turned on and the 3rd switch N2 is turned off. Thus, the coupling of the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND is no longer maintained and the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND are coupled. Accordingly, the voltage VCC is supplied to the pull-up power supply node PUSPL_ND. The pull-down power node PD_ND and the pull-down power supply node PDSPL_ND are coupled to each other, so the voltage VSS is supplied to the pull-down power supply node PDSPL_ND. As a result, the voltage of the pull-up power supply node PUSPL_ND rises to a level of the voltage VCC, and the voltage of the pull-down power supply node PDSPL_ND drops to the level of the voltage VSS. The 1st latch node Q is being grounded (VSS) by the transistor N3 that is turned on in response to the delayed reset signal RESET_D. As a result, the voltage of the 1st latch node Q drops to the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N rises to a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

In a period T4, the delayed reset signal RESET_D is deactivated, and thus the transistor N3 of the reset unit 400 is turned off. Thus, the coupling of the 1st latch node Q and the ground node to is no longer maintained. As a result, in the period T4, the voltage of the 1st latch node Q maintains the level of the voltage VSS by the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N maintains the level of the voltage VCC by the pull-up power supply node PUSPL_ND.

The latch circuit in accordance with the present invention include a plurality of latches 100_1~100_N as in an embodiment of FIG. 4. That is, the latch circuit may include the latches 100_1~100_N a power supply unit 200, a delay unit 300 and a reset unit 410.

The power supply unit 200 and the delay unit 300 have constructions and operating principles same as those of the power supply unit 200 and the delay unit 300, respectively, described with reference to FIG. 2.

Each of the latches 100_1~100_N latches data in response to power supplied to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND. Each of the latches 100_1~100_N has a construction and operating principle same as the latch 100_1 described with reference to FIG. 2.

The reset unit 410 resets the latches 100_1~100_N to a 1st level in response to a delayed reset signal RESET_D. FIG. 4 illustrates an example in which the reset unit 410 resets the latches 100_1~100_N to a low level when the delayed reset signal RESET_D is activated. The reset unit 410 includes N transistors 410_1~410_N corresponding to the respective latches 100_1~100_N. Each of the N transistors 410_1~410_N is turned on when the delayed reset signal RESET_D is activated, and is coupled to the ground and the 1st latch nodes Q of the corresponding one of the latches 100_1~100_N.

The reset operation of the latch circuit of FIG. 4 is same as the reset operation of the latch circuit of FIG. 2 except that all the latches 100_1~100_N are reset at once.

FIG. 5 is a diagram showing a latch circuit in accordance with a 3rd embodiment of the present invention.

The latch circuit of FIG. 5 differs from the latch circuit of FIG. 2 in the type of power supplied to the pull-up and

7

pull-down power supply nodes PUSPL_ND and PDSPL_ND in response to the activated reset signal RESET.

The latch circuit of FIG. 5 may include a latch 101_1, a power supply unit 201, a delay unit 300, and a reset unit 400.

The latch 101_1 has a construction and operating principle same as that of the latch 100_1 described with reference to FIG. 2.

The delay unit 300 and the reset unit 400 have constructions and operating principles same as those of the delay unit 300 and the reset unit 400, respectively, described with reference to FIG. 2.

The power supply unit 201 supplies the same power to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND in response to a reset signal RESET. The power supply unit 201 supplies a pull-up voltage VCC to the pull-up power supply node PUSPL_ND and a pull-down voltage VSS to the pull-down power supply node PDSPL_ND in response to the deactivated reset signal RESET. The power supply unit 201 supplies the voltage VSS to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND in response to the activated reset signal RESET. In the power supply unit 201, a pull-up power node PU_ND supplies a pull-up voltage. A pull-down power node PD_ND is coupled and supplies a pull-down voltage to the pull-down power supply node PDSPL_ND regardless of the reset signal RESET. A 1st switch P1 couples the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND in response to the deactivated reset signal RESET, and a 3rd switch N2 couples the pull-up and the pull-down power supply nodes PUSPL_ND and PDSPL_ND in response to the activated reset signal RESET.

FIG. 6 is a timing diagram showing the reset operation of the latch circuit shown in FIG. 5.

Data of a high level is latched the 1st latch Q prior to the reset operation of the latch circuit. Since the reset signal RESET is in a low level during a period T0, the 1st switch P1 is turned on and thus the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND are coupled to each other, so the voltage VCC is supplied to the pull-up power supply node PUSPL_ND. Since the pull-down power supply node PDSPL_ND is coupled to the pull-down power node PD_ND regardless of the reset signal RESET, the voltage VSS is supplied to the pull-down power supply node PDSPL_ND. Since the 3rd switch N2 is turned off in response to the deactivated reset signal RESET, the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND are not coupled. Accordingly, the voltage of the pull-up power supply node PUSPL_ND becomes a level of the voltage VCC, and the voltage of the pull-down power supply node PDSPL_ND becomes a level of the voltage VSS. The voltage of the 1st latch Q becomes a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND, and the voltage of the 2nd latch node Q_N of the latch 101_1 becomes a level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND.

In a period T1, the reset signal RESET is activated. The 1st switch P1 is turned off in response to the activated reset signal RESET, and thus the coupling of the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND is no longer maintained. Thus, the voltage VCC is no longer supplied to the pull-up power supply node PUSPL_ND. The voltage VSS is supplied to the pull-down power supply node PDSPL_ND because the pull-down power node PD_ND and the pull-down power supply node PDSPL_ND are coupled regardless of the reset signal RESET. Accordingly, the voltage of the pull-down power supply node PDSPL_ND maintains the level of the voltage VSS. The 3rd switch N2 is turned

8

on in response to the activated reset signal RESET and thus the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND are coupled to each other, so the voltage of the pull-up power supply node PUSPL_ND drops to the level of the voltage VSS. As a result, the voltage of the 1st latch Q drops to the level of the voltage VSS by the voltage of the pull-up power supply node PUSPL_ND, and the voltage of the 2nd latch node Q_N maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND.

The delay unit 300 generates a delayed reset signal RESET_D, whose activation period is overlapped with the activation period of the reset signal RESET for a period T2, by delaying the reset signal RESET. The transistor N3 of the reset unit 400 is turned on in response to the reset signal RESET_D in the period T2, and thus the 1st latch node Q is grounded (VSS). The voltage of each of the 1st and 2nd latch nodes Q and Q_N maintains a level of the voltage of the pull-up power supply node PUSPL_ND or the pull-down power supply node PDSPL_ND, that is, a level of the voltage VSS.

In a period T3, the reset signal RESET is deactivated. In response to the deactivated reset signal RESET, the 3rd switch N2 is turned off and thus the coupling of the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND is no longer maintained. The 1st switch P1 is turned on and thus the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND are coupled. Thus, the voltage VCC is supplied to the pull-up power supply node PUSPL_ND. As a result, the voltage of the pull-up power supply node PUSPL_ND rises to a level of the voltage VCC. The voltage of the pull-down power supply node PDSPL_ND coupled to the pull-down power node PD_ND regardless of the reset signal RESET maintains the level of the voltage VSS. The 1st latch node Q is grounded (VSS) by the transistor N3 turned on in response to the delayed reset signal RESET_D. As a result, the voltage of the 1st latch node Q maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N rises to a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

In a period T4, the delayed reset signal RESET_D is deactivated, and thus the transistor N3 of the reset unit 400 is turned off. Thus, the coupling of the 1st latch node Q and the ground node is no longer maintained. As a result, in the period T4, the voltage of the 1st latch node Q maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N maintains the level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

FIG. 7 is a diagram showing a latch circuit in accordance with a 4th embodiment of the present invention.

The latch circuit of FIG. 7 differs from the latch circuit of FIG. 5 in that it includes a plurality of latches 101_1~101_N. That is, the latch circuit of FIG. 7 may include the latches 101_1~101_N, a power supply unit 201, a delay unit 300, and a reset unit 411.

The power supply unit 201 and the delay unit 300 have constructions and operating principles same as those of the power supply unit 201 and the delay unit 300, respectively, described with reference to FIG. 5.

Each of the latches 101_1~101_N latches data in response to power supplied to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND. Each of the latches 101_1~101_N has a construction and operating principle same as that of the latch 101_1 described with reference to FIG. 5.

The reset unit **411** resets the latches **101_1~101_N** to a 1st level in response to a delayed reset signal **RESET_D**. FIG. 7 illustrates an example in which the reset unit **411** resets the latches **101_1~101_N** to a low level when the delayed reset signal **RESET_D** is activated. The reset unit **411** include N transistors **411_1~411_N** corresponding to the respective latches **101_1~101_N**. Each of the transistors **411_1~411_N** is turned on when the delayed reset signal **RESET_D** is activated and is coupled to the ground and the 1st latch node Q of a corresponding latch of the latches **101_1~101_N**.

The reset operation of the latch circuit of FIG. 7 is same as the reset operation of the latch circuit of FIG. 5 in that all the latches **101_1~101_N** are reset at once.

The latch circuits configured to perform the reset operations using one reset signal **RESET** have been described so far. Latch circuits configured to perform reset operations using two reset signals **RESET** and **SET** are described below.

FIG. 8 is a diagram showing a latch circuit in accordance with a 5th embodiment of the present invention.

The latch circuit may include a latch **102_1**, a power supply unit **202**, a delay unit **301**, and a reset unit **420**.

The latch **102_1** latches data in response to power supplied to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND**. The latch **102_1** has a construction and operating principle same as that of the latch **100_1** described with reference to FIG. 2.

The power supply unit **202** supplies the same power to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** when a 1st reset signal **RESET** or a 2nd reset signal **SET** is activated. The power supply unit **202** supplies a pull-up voltage **VCC** to the pull-up power supply node **PUSPL_ND** and a pull-down voltage **VSS** to the pull-down power supply node **PDSPL_ND** when both the 1st and 2nd reset signals **RESET** and **SET** are deactivated. The power supply unit **202** supplies the same power (for example, voltage having a middle level between the voltages **VCC** and **VSS**) to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** when one of the 1st and 2nd reset signals **RESET** and **SET** is activated.

When one of the 1st and 2nd reset signals **RESET** and **SET** is activated, the power supply unit **202** does not supply the voltages **VCC** and **VSS** to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND**, but couples and supplies voltage of the middle level between the voltages **VCC** and **VSS** to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND**. For example, the power supply unit **202** includes a pull-up power node **PU_ND** supplying a pull-up voltage, a pull-down power node **PD_ND** supplying a pull-down voltage, a 1st switch **P1** coupling the pull-up power node **PU_ND** and the pull-up power supply node **PUSPL_ND** when both the 1st and 2nd reset signals **RESET** and **SET** are deactivated, a 2nd switch **N1** coupling the pull-down power node **PD_ND** and the pull-down power supply node **PDSPL_ND** when both the 1st and 2nd reset signals **RESET** and **SET** are deactivated, and a 3rd switch **N2** coupling the pull-up and the pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** when one of the 1st and 2nd reset signals **RESET** and **SET** is activated.

The delay unit **301** generates a 1st and 2nd delayed reset signals **RESET_D** and **SET_D** by delaying the 1st and 2nd reset signals **RESET** and **SET**. The delay unit **301** generates the 1st delayed reset signal **RESET_D** whose activation period is partially overlapped with the activation period of the 1st reset signal **RESET**, preferably to a minimum. The delay unit **301** also generates the 2nd delayed reset signal **SET_D**

whose activation period is partially overlapped with the activation period of the 2nd reset signal **SET**, preferably to a minimum.

The reset unit **420** resets the latch **102_1** to a 1st level in response to the 1st delayed reset signal **RESET_D** and resets the latch **102_1** to a 2nd level in response to the 2nd delayed reset signal **SET_D**. FIG. 8 illustrates an example in which the reset unit **420** is designed to reset the latch **102_1** to a low level when the 1st delayed reset signal **RESET_D** is activated and to reset the latch **102_1** to a high level when the 2nd delayed reset signal **SET_D** is activated. The reset unit **420** includes 1st and 2nd transistors **421_1** and **422_1**. The 1st transistor **421_1** is turned on in response to the 1st delayed reset signal **RESET_D** and coupled to the ground and the 1st latch node Q. The 2nd transistor **422_1** is turned on in response to the 2nd delayed reset signal **SET_D** and coupled to the ground node (**VSS**) and the 2nd latch node **Q_N**.

FIG. 9 is a timing diagram showing the reset operation of the latch circuit shown in FIG. 8

Operation of Resetting the Latch **102_1** to a Low Level in Response to the 1st Delayed Reset Signal **RESET_D** (Periods **T0~T4**)

The operation of resetting the latch **102_1** to a low level in response to the 1st delayed reset signal **RESET_D** is same as the reset operation of the latch **100_1** described with reference to FIG. 3. Data of a high level may be latched in the 1st latch node Q prior to the reset operation of the latch circuit. During a period **T0**, the 1st and the 2nd switches **P1** and **N1** are turned on and the 3rd switch **N2** is turned off because both the 1st and 2nd reset signals **RESET** and **SET** are in a low level. Accordingly, the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** are not coupled to each other, and the pull-up power node **PU_ND** and the pull-up power supply node **PUSPL_ND** are coupled to each other, so the voltage **VCC** is supplied to the pull-up power supply node **PUSPL_ND**. Since the pull-down power node **PD_ND** and the pull-down power supply node **PDSPL_ND** are coupled to each other, the voltage **VSS** is supplied to the pull-down power supply node **PDSPL_ND**. As a result, the voltage of the pull-up power supply node **PUSPL_ND** becomes a level of the voltage **VCC**, and the voltage of the pull-down power supply node **PDSPL_ND** becomes a level of the voltage **VSS**. The voltage of the 1st latch node Q becomes a level of the voltage **VCC** by the voltage of the pull-up power supply node **PUSPL_ND**, and the voltage of the 2nd latch node **Q_N** becomes a level of the voltage **VSS** by the voltage of the pull-down power supply node **PDSPL_ND**.

In a period **T1**, the 1st reset signal **RESET** is activated. In response to the activated 1st reset signal **RESET**, the 1st and the 2nd switches **P1** and **N1** are turned off and the 3rd switch **N2** is turned on. Accordingly, the coupling of the pull-up power node **PU_ND** and the pull-up power supply node **PUSPL_ND** is no longer maintained, and thus the voltage **VCC** is no longer supplied to the pull-up power supply node **PUSPL_ND**. The coupling of the pull-down power node **PD_ND** and the pull-down power supply node **PDSPL_ND** is no longer maintained, and thus the voltage **VSS** is no longer supplied to the pull-down power supply node **PDSPL_ND**. The pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** are coupled to each other by the turned-on 3rd switch **N2**. As a result, the voltage of the pull-up power supply node **PUSPL_ND** drops to a middle level between the voltages **VCC** and **VSS**, and thus the voltage of the pull-down power supply node **PDSPL_ND** rises to the middle level between the voltages **VCC** and **VSS**. As a result, the voltage of the pull-up and pull-down power supply nodes **PUSPL_ND**

11

and PDSPL_ND respectively drop and rise to the middle level between the voltages VCC and VSS.

The delay unit **301** generates the 1st delayed reset signal RESET_D, whose activation period is overlapped with the activation period of the 1st reset signal RESET for a period T2, by delaying the 1st reset signal RESET. The 1st transistor **421_1** is turned on in response to the 1st reset signal RESET_D in the period T2, and thus the 1st latch node Q is grounded (VSS). The voltage of each of the 1st latch node Q and the 2nd latch node Q_N maintains a level of the voltage of the pull-up power supply node PUSPL_ND or the pull-down power supply node PDSPL_ND, that is, the levels between the voltages VCC and VSS.

In a period T3, the 1st reset signal RESET is deactivated. Since both the 1st and 2nd reset signals RESET and SET are in a low level, the 1st and the 2nd switches P1 and N1 are turned on and the 3rd switch N2 is turned off. Thus, the coupling of the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND is no longer maintained and the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND are coupled to each other, so the voltage VCC is supplied to the pull-up power supply node PUSPL_ND. The pull-down power node PD_ND and the pull-down power supply node PDSPL_ND are coupled to each other, and thus the voltage VSS is supplied to the pull-down power supply node PDSPL_ND. As a result, the voltage of the pull-up power supply node PUSPL_ND rises to a level of the voltage VCC, and the voltage of the pull-down power supply node PDSPL_ND drops to a level of the voltage VSS. The 1st latch node Q is being grounded (VSS) by the 1st transistor **421_1** turned on in response to the 1st delayed reset signal RESET_D. As a result, the voltage of the 1st latch node Q drops to a level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND and the voltage of the 2nd latch node Q_N rises to a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

In a period T4, the 1st delayed reset signal RESET_D is deactivated and thus the 1st transistor **421_1** is turned off, thereby breaking the coupling of the 1st latch node Q and the ground node. As a result, in the period T4, the voltage of the 1st latch node Q maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N maintains the level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

Operation of Resetting the Latch **102_1** to a High Level in Response to the 2nd Delayed Reset Signal SET_D (Periods T5~T8)

As described above, in the period T4, data of a low level has been latched in the 1st latch node Q.

In a period T5, the 2nd reset signal SET is activated. In response to the activated 2nd reset signal SET, the 1st and the 2nd switches P1 and N1 are turned off and the 3rd switch N2 is turned on. Accordingly, the coupling of the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND is no longer maintained, and thus the voltage VCC is no longer supplied to the pull-up power supply node PUSPL_ND. The coupling of the pull-down power node PD_ND and the pull-down power supply node PDSPL_ND is no longer maintained, and thus the voltage VSS is no longer supplied to the pull-down power supply node PDSPL_ND. The pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND are coupled to each other by the turned-on 3rd switch N2. Thus, the voltage of the pull-up power supply node PUSPL_ND drops to the middle level between the voltages VCC and VSS, and the voltage of the pull-down power supply node PDSPL_ND rises to the middle level between the

12

voltages VCC and VSS. As a result, the voltage of the 1st latch node Q rises to the middle level between the voltages VCC and VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N drops to the middle level between the voltages VCC and VSS by the voltage of the pull-up power supply node PUSPL_ND.

The delay unit **301** generates the 2nd delayed reset signal SET_D, whose activation period is overlapped with the activation period of the 2nd reset signal SET during a period T6, by delaying the 2nd reset signal SET. The 2nd transistor **422_1**, is turned on in response to the 2nd reset signal SET_D activated and delayed in the period T6, and thus the 2nd latch node Q_N is grounded (VSS). The voltage of each of the 1st latch node Q and the 2nd latch node Q_N maintains the level of the voltage of the pull-up power supply node PUSPL_ND or the pull-down power supply node PDSPL_ND, that is, the middle level between the voltages VCC and VSS.

In a period T7, the 2nd reset signal SET is deactivated. Since both the 1st and 2nd reset signals RESET and SET are in a low level, the 1st and the 2nd switches P1 and N1 are turned on and the 3rd switch N2 is turned off. Thus, the coupling of the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND is no longer maintained and the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND are coupled to each other, so the voltage VCC is supplied to the pull-up power supply node PUSPL_ND. The pull-down power node PD_ND and the pull-down power supply node PDSPL_ND are coupled to each other, and thus the voltage VSS is supplied to the pull-down power supply node PDSPL_ND. Accordingly, the voltage of the pull-up power supply node PUSPL_ND rises to a level of the voltage VCC, and the voltage of the pull-down power supply node PDSPL_ND drops to a level of the voltage VSS. The 2nd latch node Q_N is being grounded (VSS) by the 2nd transistor **422_1** turned on in response to the 2nd delayed reset signal SET_D. As a result, the voltage of the 2nd latch node Q_N drops to a level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 1st latch node Q rises to a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

In a period T8, the coupling of the 2nd latch node Q_N and the ground node is no longer maintained because the 2nd delayed reset signal SET_D is deactivated and thus the 2nd transistor **422_1** is turned off. As a result, in the period T8, the voltage of the 2nd latch node Q_N maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 1st latch node Q maintains the level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

FIG. 10 is a diagram showing a latch circuit in accordance with a 6th embodiment of the present invention.

The latch circuit of FIG. 10 differs from the latch circuit of FIG. 8 in that it includes a plurality of latches **102_1~102_N**. That is, the latch circuit of FIG. 10 may include the latches **102_1~102_N**, a power supply unit **202**, a delay unit **301**, and a reset unit **430**.

The power supply unit **202** and the delay unit **301** have constructions and operating principle same as those of the power supply unit **202** and the delay unit **301**, respectively, described with reference to FIG. 8.

Each of the latches **102_1~102_N** latches data in response to power supplied to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND. Each of the latches **102_1~102_N** has a construction and operating principle same as that of the latch **102_1** described with reference to FIG. 8.

13

The reset unit **430** resets the latches **102_1~102_N** to a 1st level in response to a 1st delayed reset signal **RESET_D** and resets the latches **102_1~102_N** to a 2nd level in response to a 2nd delayed reset signal **SET_D**. FIG. **10** illustrates an example in which the reset unit **430** resets the latches **102_1~102_N** to a low level when the 1st delayed reset signal **RESET_D** is activated and resets the latches **102_1~102_N** to a high level when the 2nd delayed reset signal **SET_D** is activated. The reset unit **430** include 1st transistors **431_1~431_N** corresponding to the latches **102_1~102_N**, respectively, and 2nd transistors **432_1~432_N** corresponding to the latches **102_1~102_N**, respectively. Each of the 1st transistors **431_1~431_N** is turned on when the 1st delayed reset signal **RESET_D** is activated and is coupled to the ground and the 1st latch node Q of a corresponding one of the latches **102_1~102_N**. Each of the 2nd transistors **432_1~432_N** is turned on when the 2nd delayed reset signal **SET_D** is activated and is coupled to the ground and the 2nd latch node Q_N of a corresponding one of the latches **102_1~102_N**.

The reset operation of the latch circuit shown in FIG. **10** is same as the reset operation of the latch circuit shown in FIG. **8** except that all the latches **102_1~102_N** are reset at once.

FIG. **11** is a diagram showing a latch circuit in accordance with a 7th embodiment of the present invention.

The latch circuit of FIG. **11** differs from the latch circuit of FIG. **8** in the type of power supplied to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** when the 1st reset signal **RESET** or the 2nd reset signal **SET** is activated.

The latch circuit of FIG. **11** may include a latch **103**, a power supply unit **203**, a delay unit **301**, and a reset unit **420**.

The latch **103_1** has a construction and operating principle same as that of the latch **102_1** described with reference to FIG. **8**.

The delay unit **301** and the reset unit **420** have constructions and operating principles same as those of the delay unit **301** and the reset unit **420**, respectively, described with reference to FIG. **8**.

The power supply unit **203** supplies the same power to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** when a 1st reset signal **RESET** or a 2nd reset signal **SET** is activated. The power supply unit **203** supplies a pull-up voltage **VCC** to the pull-up power supply node **PUSPL_ND** and a pull-down voltage **VSS** to the pull-down power supply node **PDSPL_ND** when both the 1st and 2nd reset signals **RESET** and **SET** are deactivated. The power supply unit **203** supplies the voltage **VSS** to the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** when one of the 1st and 2nd reset signals **RESET** and **SET** is activated. In the power supply unit **203**, a pull-up power node **PU_ND** supplies a pull-up voltage. A pull-down power node **PD_ND** is coupled to the pull-down power supply node **PDSPL_ND** regardless of the 1st and the 2nd reset signals **RESET** and **SET**, and supplies a pull-down voltage. A 1st switch **P1** couples the pull-up power node **PU_ND** and the pull-up power supply node **PUSPL_ND** when both the 1st and 2nd reset signals **RESET** and **SET** are deactivated. A 3rd switch **N2** couples the pull-up and the pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** when the 1st reset signal **RESET** or the 2nd reset signal **SET** is activated.

FIG. **12** is a timing diagram showing the reset operation of the latch circuit shown in FIG. **11**.

Operation of Resetting the Latch **103_1** to a Low Level in Response to a 1st Delayed Reset Signal **RESET_D** (Periods **T0~T4**)

14

The operation of resetting the latch **103_1** to a low level in response to the 1st delayed reset signal **RESET_D** is same as the reset operation of the latch **102_1** described with reference to FIG. **9**. Data of a high level may be latched in the 1st latch node Q prior to the reset operation of the latch circuit. During a period **T0**, the 1st switch **P1** is turned on and the 3rd switch **N2** is turned off because both the 1st and 2nd reset signals **RESET** and **SET** are in a low level. Accordingly, the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** are not coupled to each other, and the pull-up power node **PU_ND** and the pull-up power supply node **PUSPL_ND** are coupled to each other, so the voltage **VCC** is supplied to the pull-up power supply node **PUSPL_ND**. Since the pull-down power supply node **PDSPL_ND** is coupled to the pull-down power node **PD_ND** regardless of the 1st and the 2nd reset signals **RESET** and **SET**, the voltage **VSS** is supplied to the pull-down power supply node **PDSPL_ND**. As a result, the voltage of the pull-up power supply node **PUSPL_ND** becomes a level of the voltage **VCC**, and the voltage of the pull-down power supply node **PDSPL_ND** becomes a level of the voltage **VSS**. The voltage of the 1st latch node Q becomes a level of the voltage **VCC** by the voltage of the pull-up power supply node **PUSPL_ND**, and the voltage of the 2nd latch node Q_N becomes a level of the voltage **VSS** by the voltage of the pull-down power supply node **PDSPL_ND**.

In a period **T1**, the 1st reset signal **RESET** is activated. Since the 1st switch **P1** is turned off in response to the activated 1st reset signal **RESET** and thus the coupling of the pull-up power node **PU_ND** and the pull-up power supply node **PUSPL_ND** is no longer maintained, the voltage **VCC** is no longer supplied to the pull-up power supply node **PUSPL_ND**. Since the pull-down power supply node **PDSPL_ND** is coupled to the pull-down power node **PD_ND** regardless of the 1st and the 2nd reset signals **RESET** and **SET**, the voltage **VSS** is supplied to the pull-down power supply node **PDSPL_ND**. As a result, the voltage of the pull-down power supply node **PDSPL_ND** maintains the level of the voltage **VSS**. Since the 3rd switch **N2** is turned on in response to the activated 1st reset signal **RESET** and thus the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** are coupled to each other, the voltage of the pull-up power supply node **PUSPL_ND** drops to a level of the voltage **VSS**. As a result, the voltage of the 1st latch node Q drops to the level of the voltage **VSS** by the voltage of the pull-up power supply node **PUSPL_ND** and the voltage of the 2nd latch node Q_N maintains the level of the voltage **VSS** by the voltage of the pull-down power supply node **PDSPL_ND**.

The delay unit **301** generates the 1st delayed reset signal **RESET_D**, whose activation period is overlapped with the activation period of the 1st reset signal **RESET** for a period **T2**, by delaying the 1st reset signal **RESET**. The 1st transistor **421_1** is turned on in response to the 1st reset signal **RESET_D** in the period **T2**, and thus the 1st latch node Q is grounded (**VSS**). The voltage of each of the 1st latch node Q and the 2nd latch node Q_N maintains the level of the pull-up power supply node **PUSPL_ND** or the pull-down power supply node **PDSPL_ND** that is, the level of the voltage **VSS**.

In a period **T3**, the 1st reset signal **RESET** is deactivated. Since both the 1st and 2nd reset signals **RESET** and **SET** are in a low level, the 3rd switch **N2** is turned off and thus the coupling of the pull-up and pull-down power supply nodes **PUSPL_ND** and **PDSPL_ND** is no longer maintained. Since the 1st switch **P1** is turned on and thus the pull-up power node **PU_ND** and the pull-up power supply node **PUSPL_ND** are coupled to each other, the voltage **VCC** is supplied to the pull-up power supply node **PUSPL_ND**. As a result, the volt-

15

age of the pull-up power supply node PUSPL_ND rises to a level of the voltage VCC. Since the pull-down power supply node PDSPL_ND is coupled to the pull-down power node PD_ND regardless of the 1st and the 2nd reset signals RESET and SET, the voltage of the pull-down power supply node PDSPL_ND maintains the level of the voltage VSS. The 1st latch node Q is grounded (VSS) by the 1st transistor **421_1** turned on in response to the 1st delayed reset signal RESET_D. As a result, the voltage of the 1st latch node Q maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N rises to a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

In a period T4, since the 1st delayed reset signal RESET_D is deactivated, the 1st transistor **421_1** is turned off, thereby breaking the coupling of the 1st latch node Q and the ground node. As a result, in the period T4, the voltage of the 1st latch node Q maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N maintains the level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

Operation of Resetting the Latch **103_1** to a High Level in Response to the 2nd Delayed Reset Signal SET_D (Period T5~T8)

As described above, in the period T4, data of a low level is latched in the 1st latch node Q

In a period T5, the 2nd reset signal SET is activated. The 1st switch P1 is turned off in response to the activated 2nd reset signal SET and thus the coupling of the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND is no longer maintained, so the voltage VCC is no longer supplied to the pull-up power supply node PUSPL_ND. Since the pull-down power supply node PDSPL_ND is coupled to the pull-down power node PD_ND regardless of the 1st and the 2nd reset signals RESET and SET, the voltage VSS is supplied to the pull-down power supply node PDSPL_ND. Accordingly, the voltage of the pull-down power supply node PDSPL_ND maintains the level of the voltage VSS. The 3rd switch N2 is turned on in response to the activated 2nd reset signal SET and thus the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND are coupled to each other, so the voltage of the pull-up power supply node PUSPL_ND drops to a level of the voltage VSS. As a result, the voltage of the 1st latch node Q maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 2nd latch node Q_N drops to a level of the voltage VSS by the voltage of the pull-up power supply node PUSPL_ND.

The delay unit **301** generates a 2nd delayed reset signal SET_D, whose activation period is overlapped with the activation period of the 2nd reset signal SET during a period T6, by delaying the 2nd reset signal SET. The 2nd latch node Q_N is grounded because the 2nd transistor **422_1** is turned on in response to the 2nd reset signal SET_D activated and delayed in the period T6. The voltage of each of the 1st latch node Q and the 2nd latch node Q_N maintains the level of the pull-up power supply node PUSPL_ND or the pull-down power supply node PDSPL_ND, that is, the level of the voltage VSS.

In a period T7, the 2nd reset signal SET is deactivated. Since both the 1st and 2nd reset signals RESET and SET are in a low level, the 3rd switch N2 is turned off and thus the coupling of the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND is no longer maintained. Since the 1st switch P1 is turned on and thus the pull-up power node PU_ND and the pull-up power supply node PUSPL_ND are coupled to each other, the voltage VCC is supplied to the

16

pull-up power supply node PUSPL_ND. As a result, the voltage of the pull-up power supply node PUSPL_ND rises to a level of the voltage VCC. Since the pull-down power supply node PDSPL_ND is coupled to the pull-down power node PD_ND regardless of the 1st and the 2nd reset signals RESET and SET, the voltage of the pull-down power supply node PDSPL_ND maintains the level of the voltage VSS. The 2nd latch node Q_N is being grounded (VSS) by the 2nd transistor **422_1** turned on in response to the 2nd delayed reset signal SET_D. As a result, the voltage of the 2nd latch node Q_N maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND and the voltage of the 1st latch node Q rises to a level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

In a period T8, the 2nd delayed reset signal SET_D is deactivated and thus the 2nd transistor **422_1** is turned off, thereby breaking the coupling of the 2nd latch node Q_N and the ground node. As a result, in the period T8, the voltage of the 2nd latch node Q_N maintains the level of the voltage VSS by the voltage of the pull-down power supply node PDSPL_ND, and the voltage of the 1st latch node Q maintains the level of the voltage VCC by the voltage of the pull-up power supply node PUSPL_ND.

FIG. 13 is a diagram showing a latch circuit n accordance with an 8th embodiment of the present invention.

The latch circuit of FIG. 13 differs from the latch circuit of FIG. 11 in that it includes a plurality of latches **103_1~103_N**. That is the latch circuit of FIG. 13 may include the latches **103_1~103_N**, a power supply unit **203**, a delay unit **301**, and a reset unit **430**.

The power supply unit **203** and the delay unit **301** have constructions and operating principles same as those of the power supply unit **203** and the delay unit **301**, respectively, described with reference to FIG. 11.

Each of the latches **103_1~103_N** latches data in response to power supplied to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND. Each of the latches **103_1~103_N** has a construction and operating principle same as that of the latch **103_1** described with reference to FIG. 11.

The reset unit **430** resets the plurality of latches **103_1~103_N** to a 1st level in response to a 1st delayed reset signal RESET_D and resets the plurality of latches **103_1~103_N** to a 2nd level in response to a 2nd delayed reset signal SET_D. FIG. 13 illustrates an example in which the reset unit **430** resets the latches **103_1~103_N** to a low level when the 1st delayed reset signal RESET_D is activated, and resets the latches **103_1~103_N** to a high level when the 2nd delayed reset signal SET_D is activated. The reset unit **430** include 1st transistors **431_1~431_N** corresponding to the latches **103_1~103_N**, respectively, and 2nd transistors **432_1~432_N** corresponding to the latches **103_1~103_N**, respectively. Each of the 1st transistors **431_1~431_N** is turned on when the 1st delayed reset signal RESET_D is activated, and is coupled to the ground and the 1st latch node Q of a corresponding one of the latches **103_1~103_N**. Each of the 2nd transistors **432_1~432_N** is turned on when the 2nd delayed reset signal SET_D is activated, and is coupled to the ground and the 2nd latch node Q_N of a corresponding one of the latches **103_1~103_N**.

The reset operation of the latch circuit of FIG. 13 is same as the reset operation of the latch circuit of FIG. 11 except that all the latches **103_1~103_N** are reset at once.

FIG. 14 is a diagram showing a nonvolatile memory device in accordance with an embodiment of the present invention.

17

The nonvolatile memory device of FIG. 14 may include memory cells 610_1~610_N, page buffers 700_1~700_N a power supply unit 800, a delay unit 900, and a reset unit 950.

The page buffers 700_1~700_N access data stored in the memory cells 610_1~610_N, respectively. The page buffers 700_1~700_N perform a program operation for storing data in the memory cells 610_1~610_N and a read operation for reading data from the memory cells 610_1~610_N. Each of the page buffers 700_1~700_N includes one or more latches 710_1~710_N that operate in response to power supplied to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND.

The power supply unit 800 supplies the same power (for example, voltage of a level between a pull-up voltage and a pull-down voltage) to the pull-up and pull-down power supply nodes PUSPL_ND and PDSPL_ND when a 1st reset signal RESET or a 2nd reset signal SET is activated. The power supply unit 800 has a construction and operating principle same as that of the power supply unit 202 described with reference to FIG. 10.

The delay unit 900 generates a 1st and 2nd delayed reset signals RESET_D and SET_D by delaying the 1st and 2nd reset signals RESET and SET. The delay unit 900 has a construction and operating principle same as that of the delay unit 900 described with reference to FIG. 10.

The reset unit 950 resets the latches 710_1~710_N to a 1st level in response to the 1st delayed reset signal RESET_D and resets the latches 710_1~710_N to a 2nd level in response to the 2nd delayed reset signal SET_D. FIG. 14 illustrates an example in which the reset unit 950 resets the latches 710_1~710_N to a low level when the 1st delayed reset signal RESET_D is activated, and resets the latches 710_1~710_N to a high level in response to the 2nd delayed reset signal SET_D. The reset unit 950 has a construction and operating principle same as that of the reset unit 430 described with reference to FIG. 10.

The nonvolatile memory device may have to reset the latches 710_1~710_N to the 1st or 2nd level at once during a program operation or a read operation. An operation of resetting the latches 710_1~710_N at once is same as the reset operation of the latch circuit described with reference to FIG. 10. The latches 710_1~710_N are precharged with voltage having a level between the 1st and 2nd levels (for example, voltage of a middle level), and then reset to the 1st level. That is, the voltages of the latches 710_1~710_N are reset step by step from a level between the 1st and 2nd level to the 1st level. Accordingly, in accordance with an embodiment of the present invention, a peak current may be lowered as compared with a conventional nonvolatile memory device configured to reset a plurality of latches at once from the 2nd level to the 1st level. Thus, a power drop occurring due to an excessive peak current may be prevented.

FIG. 14 illustrates an example in which the latches 710_1~710_N are reset in response to the two reset signals RESET and SET. In some embodiments, the nonvolatile memory device of the present invention may be designed to reset the latches 710_1~710_N in response to one reset signal RESET. In this case, the nonvolatile memory device may be designed without the 2nd reset signal SET and the 2nd delayed reset signal SET_D shown in FIG. 14.

The latch circuit in accordance with the present invention may be applied to nonvolatile memory devices besides various types of IC chips.

In accordance with the embodiments of the present invention, a plurality of latches may be reset with a minimum current and a minimum reset time. Accordingly, a power drop occurring due to an excessive peak current may be prevented.

18

While the present invention has been described with respect to the specific embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A latch circuit, comprising:

a plurality of latches configured to operate in response to power supplied to a pull-up power supply node and a pull-down power supply node;

a delay unit configured to generate a delayed reset signal by delaying a reset signal;

a power supply unit configured to supply a pull-up voltage to the pull-up power supply node and a pull-down voltage to the pull-down power supply node when the reset signal is deactivated, and supply an identical voltage to the pull-up power supply node and the pull-down power supply node when the reset signal is activated; and

a reset unit configured to reset the plurality of latches to a reset level when the delayed reset signal is activated, wherein an activation period of the reset signal and an activation period of the delayed reset signal at least partially overlap each other, and the pull-up power supply node and the pull-down power supply node have a level of the identical voltage when the delayed reset signal is activated.

2. A nonvolatile memory device, comprising:

a plurality of memory cells;

a plurality of page buffers configured to access data stored in the respective memory cells and each comprising one or more latches operating in response to power supplied to a pull-up power supply node and a pull-down power supply node;

a delay unit configured to generate a delayed reset signal by delaying a reset signal;

a power supply unit configured to supply a pull-up voltage to the pull-up power supply node and a pull-down voltage to the pull-down power supply node when the reset signal is deactivated, and supply an identical voltage to the pull-up power supply node and the pull-down power supply node when the reset signal is activated; and

a reset unit configured to reset the plurality of latches to a reset level when the delayed reset signal is activated, wherein an activation period of the reset signal and an activation period of the delayed reset signal at least partially overlap each other, and the pull-up power supply node and the pull-down power supply node have a level of the identical voltage when the delayed reset signal is activated.

3. The latch circuit of claim 1, wherein the identical voltage includes the middle level between the pull pull-up voltage and the pull-down voltage,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node, couples a pull-down power node to the pull-down power supply node, and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node, doesn't couple the pull-down power node and the pull-up power supply node, and couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the delayed reset signal is activated.

19

4. The latch circuit of claim 3, wherein the power supply unit comprises:

a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal;

a 2nd switch configured to couple the pull-down power node and the pull-down power supply node when the reset signal is deactivated reset signal; and

a 3rd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprises:

a 4th switch configured to supply the pull-down voltage to the 1st latch node when the delayed reset signal is activated.

5. The latch circuit of claim 1, wherein the identical voltage includes the pull-down voltage,

wherein the power supply unit supplies the pull-down voltage to the pull-down power supply node,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node and couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the delayed reset signal is activated.

6. The latch circuit of claim 5, wherein the power supply unit comprises:

a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal; and

a 2nd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprises:

a 3rd switch configured to supply the pull-down voltage to the 1st latch node when the delayed reset signal is activated.

7. The nonvolatile memory device of claim 2, wherein the identical voltage includes the middle level between the pull pull-up voltage and the pull-down voltage,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node, couples a pull-down power node to the pull-down power supply node, and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node, doesn't couple the pull-down power node and the pull-up power supply node, and couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the delayed reset signal is activated.

8. The nonvolatile memory device of claim 7, wherein the power supply unit comprises:

a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal;

20

a 2nd switch configured to couple the pull-down power node and the pull-down power supply node when the reset signal is deactivated reset signal; and

a 3rd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprises:

a 4th switch configured to supply the pull-down voltage to the 1st latch node when the delayed reset signal is activated.

9. The nonvolatile memory device of claim 2, wherein the identical voltage includes the pull-down voltage,

wherein the power supply unit supplies the pull-down voltage to the pull-down power supply node,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated, wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node and couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the delayed reset signal is activated.

10. The nonvolatile memory device of claim 9, wherein the power supply unit comprises:

a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal; and

a 2nd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprises:

a 3rd switch configured to supply the pull-down voltage to the 1st latch node when the delayed reset signal is activated.

11. A latch circuit, comprising:

a plurality of latches configured to operate in response to power supplied to a pull-up power supply node and a pull-down power supply node;

a delay unit configured to generate a 1st delayed reset signal by delaying a 1st reset signal and generate a 2nd delayed reset signal by delaying a 2nd reset signal;

a power supply unit configured to supply a pull-up voltage to the pull-up power supply node and a pull-down voltage to the pull-down power supply node when the reset signal is deactivated, and supply an identical voltage to the pull-up power supply node and the pull-down power supply node when the reset signal is activated; and

a reset unit configured to reset the plurality of latches to a 1st reset level when the 1st delayed reset signal is activated and reset the plurality of latches to a 2nd reset level when the 2st delayed reset signal is activated, wherein an activation period of the reset signal and an activation period of the delayed reset signal at least partially overlap each other.

12. The latch circuit of claim 11, wherein the identical voltage includes the middle level between the pull pull-up voltage and the pull-down voltage,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node, couples a pull-down power node to the pull-down power supply node, and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

21

wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node, doesn't couple the pull-down power node and the pull-up power supply node, and couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the 1st delayed reset signal is activated, and supplies the pull-down voltage to a 2nd latch node of each of the latches when the 2nd delayed reset signal is activated.

13. The latch circuit of claim **12**, wherein the power supply unit comprises:

a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal;

a 2nd switch configured to couple the pull-down power node and the pull-down power supply node when the reset signal is deactivated reset signal; and

a 3rd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprises:

a 4th switch configured to supply the pull-down voltage to the 1st latch node when the 1st delayed reset signal is activated; and

a 5th switch configured to supply the pull-down voltage to the 2nd latch node when the 2nd delayed reset signal is activated.

14. The latch circuit of claim **11**, wherein the identical voltage includes the pull-down voltage,

wherein the power supply unit supplies the pull-down voltage to the pull-down power supply node,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node and couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the 1st delayed reset signal is activated, and supplies the pull-down voltage to a 2nd latch node of each of the latches when the 2nd delayed reset signal is activated.

15. The latch circuit of claim **14**, wherein the power supply unit comprises:

a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal; and

a 2nd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprises:

a 3rd switch configured to supply the pull-down voltage to the 1st latch node when the 1st delayed reset signal is activated; and

a 4th switch configured to supply the pull-down voltage to the 2nd latch node when the 2nd delayed reset signal is activated.

16. A nonvolatile memory device, comprising:

a plurality of memory cells;

a plurality of page buffers configured to access data stored in the respective memory cells and each comprising one

22

or more latches operating in response to power supplied to a pull-up power supply node and a pull-down power supply node;

a delay unit configured to generate a 1st delayed reset signal by delaying a 1st reset signal and generate a 2nd delayed reset signal by delaying a 2nd reset signal;

a power supply unit configured to supply a pull-up voltage to the pull-up power supply node and a pull-down voltage to the pull-down power supply node when the reset signal is deactivated, and supply an identical voltage to the pull-up power supply node and the pull-down power supply node when the reset signal is activated; and

a reset unit configured to reset the plurality of latches to a 1st reset level when the 1st delayed reset signal is activated and reset the plurality of latches to a 2nd reset level when the 2nd delayed reset signal is activated,

wherein an activation period of the reset signal and an activation period of the delayed reset signal at least partially overlap each other.

17. The nonvolatile memory device of claim **16**, wherein the identical voltage includes the middle level between the pull pull-up voltage and the pull-down voltage,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node, couples a pull-down power node to the pull-down power supply node, and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node, doesn't couple the pull-down power node and the pull-up power supply node, and couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the 1st delayed reset signal is activated, and supplies the pull-down voltage to a 2nd latch node of each of the latches when the 2nd delayed reset signal is activated.

18. The nonvolatile memory device of claim **17**, wherein the power supply unit comprises:

a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal;

a 2nd switch configured to couple the pull-down power node and the pull-down power supply node when the reset signal is deactivated reset signal; and

a 3rd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprises:

a 4th switch configured to supply the pull-down voltage to the 1st latch node when the 1st delayed reset signal is activated; and

a 5th switch configured to supply the pull-down voltage to the 2nd latch node when the 2nd delayed reset signal is activated.

19. The nonvolatile memory device of claim **16**, wherein the identical voltage includes the pull-down voltage,

wherein the power supply unit supplies the pull-down voltage to the pull-down power supply node,

wherein the power supply unit couples a pull-up power node to the pull-up power supply node and doesn't couple the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated, wherein the power supply unit doesn't couple the pull-up power node and the pull-up power supply node and

23

couples the pull-up power supply node and the pull-down power supply node when the reset signal is deactivated,

wherein the reset unit supplies the pull-down voltage to a 1st latch node of each of the latches when the 1st delayed reset signal is activated, and supplies the pull-down voltage to a 2nd latch node of each of the latches when the 2nd delayed reset signal is activated.

20. The nonvolatile memory device of claim **19**, wherein the power supply unit comprises:

- a 1st switch configured to couple the pull-up power node and the pull-up power supply node when the reset signal is deactivated reset signal; and
- a 2nd switch configured couple the pull-up and the pull-down power supply nodes when the reset signal is activated, and

wherein the reset unit comprise:

- a 3rd switch configured to supply the pull-down voltage to the 1st latch node when the 1st delayed reset signal is activated; and
- a 4th switch configured to supply the pull-down voltage to the 2nd latch node when the 2nd delayed reset signal is activated.

* * * * *

24